

Fungicide sensitivity of the cucurbit powdery mildew pathogen population on Long Island, NY, determined using a seedling bioassay, 2021.

Fungicide resistance can be a major constraint to effectively managing powdery mildew in cucurbit crops. The most effective fungicides for this disease have mobility, enabling redistribution from deposition sites on upper leaf surfaces to the lower surfaces where powdery mildew develops best. They are more prone to the pathogen developing resistance because they have single-site modes of action. Resistance to FRAC code 1, 3, 7, 11, 13, and U6 fungicides has been documented in the U.S. In this study, a seedling bioassay was used to obtain site-specific information about resistance in cucurbit powdery mildew pathogen populations. Two bioassays were conducted in commercial and research plantings during the growing season. Pumpkin seeds were sown on 12 Jul and 13 Aug in 48-cell trays and kept in a growth chamber on (date?). Seedlings at about the cotyledon stage were transplanted individually to 4-in. pots and kept in a greenhouse. At approximately the 3-leaf stage, the growing tip with unexpanded leaves was removed, and then plants were sprayed to coverage with a fungicide dose. All fungicides were tested at their highest label rate, with some also tested at lower doses. Luna Privilege (FRAC code 7) was used rather than Luna Experience or Luna Sensation, which are labeled for cucurbit powdery mildew, because they contain a second active ingredient (FRAC code 3 and 11, respectively) which would confound results. Applications were made with a backpack sprayer (R&D Sprayers, Opelousas, LA) using a TJ60-4004EVS nozzle delivering 50 gal/A operated at 55 psi. The next day the seedlings were organized into replications, each with one plant of each treatment plus two water-treated control plants. Each replication was placed in a different field location spot next to, but not touching leaves of, plants naturally affected by powdery mildew, with three to five replications in the same location. In bioassay 1, treated on 10 Aug, four replications were put on 11 Aug in a commercial spring planting of zucchini that had not been treated with any fungicides (Location A) and four replications were put in a research planting of zucchini that had not been treated with targeted fungicides for powdery mildew (Location B). In bioassay 2, treated on 13 Sep, five replications were put on 14 Sep in two adjacent research plantings of pumpkin where biopesticides were tested alone and in programs with Proline and Vivando (Location C) and three replications were put in a commercial pumpkin planting that had been treated with Proline and Vivando (Location D). Locations A and D were different farms. Seedlings remained there for the rest of the day (6-8 hours) to be exposed to spores dispersed by wind, then the seedlings were returned to the greenhouse until symptoms developed. Seedlings regularly received water with 12-5-19 fertilizer applied to the top of the pot so leaves stayed dry and any new growth was removed. Severity of powdery mildew was assessed as percent coverage with symptoms on the upper surface of each leaf at 13 d (data not shown) and 21 d after exposure to powdery mildew for bioassay 1 and at 8 and 13 d after exposure to powdery mildew for bioassay 2. Values were averaged to obtain a single value per plant for analysis. Data were analyzed with one-way analysis of variance (ANOVA) and Tukey's honest significance test (HSD) to separate means using JMP statistical software.

Very few symptoms of powdery mildew developed on seedlings in bioassay 1, including on the water-treated control seedlings, although symptoms were common on the plants at the locations used, in particular the commercial crop (Location A). The pathogen was likely suppressed by a period of hot weather during the first week after infection when temperatures in the greenhouse exceeded 100°F during the day. Results from bioassay 1 are somewhat similar to bioassay 2, suggesting that when severity is very low some meaningful conclusions can be drawn but should not be considered definitive. In the late season bioassay (bioassay 2), Topsin M (FRAC code 1), Flint Extra (11), and Endura (7) were ineffective indicating a high frequency of resistance to these chemistries. Resistance to these fungicides have been detected commonly in the past. Torino (U6) and Quintec (13) exhibited good efficacy at highest and below label rates (78-99% control) indicating low frequency of resistance present in the pathogen populations. Resistance to these fungicides have been detected in the past associated with control failure. Resistance to Torino was detected in the 2020 bioassay. These fungicides were not applied at any of the locations used. Rally (3), Luna Privilege (7), and Vivando (50) were very effective (96-100% control) at full and reduced doses, suggesting that applying Vivando and another FRAC 3 fungicide (Proline) at these locations did not result in selection for resistance to these chemistries. Luna Privilege and Vivando at all tested rates were more effective than Torino applied at labeled field rate based on 27 Sep assessments (13 days after field exposure).

Treatment and amount/A	Powdery mildew severity at 21 (bioassay 1), 8 and 13 days (bioassay 2) after field exposure (%) *, **					
	Bioassay 1		Bioassay 2			
	Location A	Location B	Location C		Location D	
	1 Sep	1 Sep	22 Sep	27 Sep	22 Sep	27 Sep
Water control	3.84 a	2.57 abc	49.5 a	82.71 a	15.96 a	44.67 a
Topsin M 8 oz	1.54 ab	4.09 a	59.6 a	88.89 a	20.99 a	53.27 a
Flint Extra 3.8 fl oz	1.10 ab	2.63 abc	51.7 a	82.28 a	18.56 a	38.19 a
Endura 6.5 oz	1.02 ab	3.51 ab	39.6 a	79.26 a	14.68 a	31.58 a
Endura 3.25 oz	0.98 ab	1.64 abcd	43.7 a	80.43 a	13.60 a	33.39 a
Torino 3.4 fl oz	0.40 b	1.04 abcd	3.8 b	18.04 b	2.05 b	7.92 b
Torino 1.7 fl oz	0.48 b	1.17 abcd				
Torino 0.85 fl oz	0.60 ab	0.61 abcd	2.6 b	10.35 bc	0.33 b	2.39 bc
Quintec 6 fl oz	0.21 b	0.36 abcd	1.0 b	7.70 bcd	0.09 b	1.56 bc
Quintec 3 fl oz	0.31 b	0.00 d				
Quintec 1.5 fl oz	0.17 b	0.20 bcd	3.0 b	15.84 b	0.25 b	1.81 bc
Quintec 0.75 fl oz	0.02 b	0.27 bcd				
Rally 5 oz	0.09 b	0.06 cd	0.5 b	1.17 de	0.67 b	0.98 bc
Rally 2.5 oz	0.10 b	0.47 abcd	0.6 b	2.96 cde	0.20 b	0.85 bc
Luna Privilege 6.84 fl oz			0.4 b	1.36 de	0.55 b	0.27 c
Luna Privilege 1.71 fl oz			0.2 b	1.18 de	0.00 b	0.48 c
Vivando 15.4 fl oz			0.5 b	0.66 e	0.00 b	0.04 c
Vivando 3.85 fl oz			0.6 b	0.69 e	0.07 b	0.03 c
<i>P-value (treatment)</i>	0.0003	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

* Numbers in each column with a letter in common are not significantly different from each other (Tukey's HSD, $P=0.05$).

** Values were square root transformed before analysis because raw data were not distributed normally. Table contains de-transformed values.